Practical guide

for the design of cropping systems less reliant on pesticides

Application in polyculture/mixed farming systems

Help sheets

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE L'AGRICULTURE DE L'AGROALIMENTAIRE ET DE LA FORÊT
Avec la contribution financière du compte d'affectation spéciale «développement agricole et rural»

Réseau Mixte Technologique Systèmes de Culture Innovants

endure® diversifying crop protection

ÉCOPHYTO
RÉDUIRE ET AMÉLIORER L'UTILISATION DES PHYTOS

Contents

List of abbreviations

The forms in this list are marked by the [a] sign in the text.

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (French environment and energy management agency)
AEM	Agro-environmental measure
CMP	Crop management plan
COMIFER	Comité Français pour le développement de la Fertilisation Raisonnée (French committee for the development of rationalised fertilisation)
CS	Cropping system
CUMA	Coopérative d'Utilisation du Matériel Agricole (cooperative of agricultural machinery users)
F	Farm
IOBC/WPRS	International Organisation for Biological and Integrated Control of noxious animals and plants – West Palaearctic Regional Section
K	Potassium
MAP	Ministère de l'Agriculture et de la Pêche (French Ministry of agriculture and fishing)
MWU	Man work unit
N	Nitrogen
OF	Organic farming
OM	Organic matter
P	Phosphorous
RMT SDCI	Réseau Mixte Technologique Systèmes de Culture Innovants (joint technology network for innovative cropping systems)
RSA	Revue Suisse Agricole (Swiss Journal of Agriculture)
SWA	Soil water availability for plants
TFI	Treatment Frequency Index
UAL	Utilised Agricultural Land
VA	Vulnerable area
ZES	Zone d'Excédent Structurel (areas with a structural surplus of nitrogen)

Help sheet H1:
Questionnaire for the diagnosis of the farm (Step 1a)

Farmer's priorities
Farmer's personal priorities (free up more time, expansion, conversion to OF[a] etc.) and possible consequences on the farm.
Technical priorities (optimising chemical soil fertilisation, better disease control etc.).

Milieu : soil, climate
Characterisation of the principal types of soil on the farm: deep or shallow/SWA/proportion of stones.
Rainy or dry climate/irrigation necessary/fields sometimes inaccessible/frost periods etc.

Local issues : environmental, economic, regional
Water sources, problems with nitrogen (VA, ZES etc.), pesticides, landscape issues, biodiversity etc.
AEM/help available for environmental measures.
Principal markets in the region/crops with no market.

Pests : weeds, diseases, animal pests
The most important problems according to the farmer, in which crops, in what types of milieu:
- Estimate the incidence (rate of presence) of pests to see if there is a real problem or if it is only felt to be a problem by the farmer.
- See if the presence of pests really leads to losses or if it is tolerable (severity of injury).
- See if identified problems affect the whole farm or only certain CS[a].

Technical-economical environment
Contracts, suppliers, markets for products, existing sales channels etc.
Sources of advice.

Production system
UAL[a], cropping pattern (crops and approximate proportions), livestock, recent changes ?
Farmer's projects: purchase of machinery, expansion, change to conservation tillage techniques etc.

Location of fields
Fields situated at a long distance from farm, fields which are difficult to access, patchwork of fields ?
Average field size.

Equipment and material
List of equipment available on the farm, available from cooperative, identified gaps.
List of buildings available.

Labour
Labour available on the farm (MWU/ha), mutual aid available ? Use of occasional labour ?

Work priorities
Peaks in work, conflicts between different jobs, conflicts with other farm activities (holiday lets etc.).

CS[a] to be worked upon and why
Rotation, location of fields.
Why: CS covers majority of farm ? Pest problems ? Costs too high ?

Help sheet H2 :

Examples of possible objectives and constraints in a CS[a]

(Step 1b)

Objectives

- → Optimisation of soil's physical fertility
- → Optimisation of chemical fertility
- → Optimisation of mineral supplies to the crop (NPK)
- → Optimisation of water supplies to the crop
- → Weed control
- → Disease control
- → Control of animal pests
- → Optimising yields
- → Optimising production quality
- → Maximising profitability
- → Reducing/not increasing working hours
- → No use of synthetic chemical products
- → Farmer's potential projects
- → ...

Constraints

- → Constraints of the milieu: soil erosion, weak structural stability, pest problems etc.
- → Technical-economic constraints: quotas, fodder requirements, material available etc.
- → Regulatory constraints: ZES, VA, AEM etc.
- → Constraints on work organisation: livestock, distant fields etc.
- → ...

Help sheet H3 :
Principal characteristics of arable crops (Step 1b, 2a)

Crops	Family				Time before return (1)	Planting of the crop				Root system (2)	Preceding crops to avoid (3)	N demands for winter crops	P demand	K demand
	Legumes	Grasses	Crucifereae	Others										
					Years	Early autumn	Late autumn	Early spring	Late spring	Fascicular (F) Taproot (T)		Strong (xxx) Average (xx) Weak (x)	Strong (xxx) Average (xx) Weak (x)	Strong (xxx) Average (xx) Weak (x)
WO		X			2		X			F	Oats	X	X	X
SO		X			2			X		F	Oats		X	X
Beet				Chenopodiaceae	3				X	T	Maize/ Rape/ Beet		xx Fodder xxx Sugar	XXX
CW		X			2		WW		SW	F	Cereals	XX	X	X
HW		X			2		WW		SW	F	Cereals	XX	X	X
Hemp				Cannabaceae	1				X	T	None		XX	X
WR			X		4	X				T	Rape/SF	XXX	XXX	X
SR			X		4		X			T	Rape/SF		XXX	X
SP		X			2		X			F	Cereals			
FB	X				5			X		T	Legumes		XX	X
Flax				Linaceae	6				X	T	Beet/ Rape/ Flax/ Grassland			x grains xx fibres
Lupin	X				3				X	T	Legumes		XX	XX
Luc	X				4				X	T	Grassland/LUC		XXX	
GM		X			1				X	F	Rape		X	XX
FM		X			1				X	F	Rape		XX	XXX
WB		X			2		X			F	WB/SB	X	XX	X
SB		X			2			X		F	WB/SB		XX	X
WP	X				6		X			T	Legumes		XX	XX
SPE	X				6			X		T	Legumes		XX	XX
BW				Polygonaceae	2				X	T	Early autumn crops	X		
Rye		X			2		X			F	None	X	X	X
Soya	X				3				X	T	Legumes		X	XX
Sorg	X				3				X	F			XX	X
TR		X			2		X			F	Spelt/TR	X	X	X
SF				Asteraceae	4				X	T	Rape/SF		X	XX

Not applicable Information not available

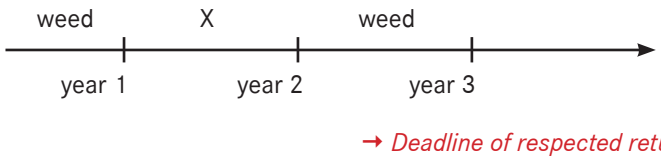
Help sheet H3 :
Principal characteristics of arable crops (Step 1b, 2a)

Abbreviations

Beet : Beet
BW : Buckwheat
CW : Common (bread) wheat
FB : Field (broad) beans
Flax : Flax
FM : Fodder maize
GM : Grain maize
Hemp : Hemp
HW : Hard (durum) wheat
Luc : Lucerne
Lupin : Lupin
Rye : Rye
SB : Spring barley
SF : Sunflower
SO : Spring oats
Sorg : Sorghum
Soya : Soya
SPE : Spring pea
Spelt : Spelt
SR : Spring rape
SW : Spring wheat
TR : Triticale
WB : Winter barley
WO : Winter oats
WP : Winter pea
WR : Winter rape
WW : Winter wheat

Remarks

(1) A time before return of two years signifies that is necessary to wait for one year before re-sowing that crop. This is illustrated in the example below for wheat.



The times before return offered here are those of the IOBC (except for beet, field bean and lupin which are taken from the Revue Suisse Agricole), and the time periods given are those for optimal pest control. These delays can be shortened, but this assumes that curative control methods have been implemented for controlling crop enemies.
These delays can vary in accordance with soil and weather conditions.
For establishing these times before the return of a crop, the existence of crops which have pests in common are not taken into account. However, it is important to take this point into consideration. The table below provides a quick list of pests which can develop in several crops.

Pests which can be common across several crops

Pests in common	Crops
Eyespot, take-all, Fusarium, septoria, smut, mildew	Straw cereals (triticale, rye and oats are less susceptible) *N.B.: Barley transmits eyespot and take-all without being susceptible.* *Maize encourages take-all in a maize-wheat rotation.*
Brown and yellow rust	Wheat, triticale
Sclerotinia	Legumes, sunflower, rape
Anthracnose, aphanomyces	Field bean, pea
Nematodes	Rape, beet
Violet root rot	Pest of beet encouraged by potato

(2) Taproot systems are generally deeper than fascicular root systems.
Similarly, in general winter crops explore deeper in the soil than the same crop sown in spring.
The characteristics of root systems can sometimes be improved by the selection of an appropriate variety.

(3) This information is based on noting the preceding crop effect of each precedent/crop coupling based on the following criteria: soil structure, diseases, animal pests, weeds and N availability.
The preceding crops to be avoided for a given crop are therefore those crops which have a negative effect on one or more of these criteria.

Sources :

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Com. Pers. **P. Viaux**.

Help sheet H4 :

Help with choosing cover crops (Step 1b, 2a)

	Soil improvement			Nutrient management		Pest management				Technical aspects (sowing and destruction)								Cost (not including volunteers)
										Sowing dates			Destruction method					
	Root system	Root exploration	Participation in stability of soil structure	Supply of nitrogen	Nitrogen trap	Negative effects	Positive effects	Appetence for slugs	Weed control	Post-harvest	End August/ start September	From September	Frost	Mechanical destruction	Chemical destruction	Ease of sowing	Speed of establishment	*Reference year: 2006*
Spring oats	F	X(X)	XXX	X	XX	Risks linked to parasitism before cereals. Allelopathic effects if destroyed late before spring barley. Risk of stem nematodes before beet.		XXX	XX	XX	XXX	XX	X	X(X)	XXX	XX	XX	XX
Winter oats	F	X(X)	XXX	X	XX			XXX	XX	XXX	XXX	XX	XX	X(X)	XXX	XX	XX	XX
Black oats	F	X(X)	XXX	X	XXX			XXX	XX	XX	XXX	XX	XX	XX	XXX	XX	XXX	XX
Wheat or Barley	F	X	XXX	X	XX			X	XX	XXX	XXX	XX	X	X(X)	XXX	XX	XX	X*
Rape	T	XXX	X	XX	XXX	Risk of sclerotinia before rape, pea, bean, soya and sunflower. Destroy early before maize. Nematode risk in beet. Not recommended before flax because of verticillium. Cruciferous clubroot risk before rape.	Positive effect on wheat on wheat (breaks parasite cycle).	X	XX(X)	XXX	XXX	X	X	XX	XX(X)	XXX	XXX	XXX
Fenugreek	T	XXX		XXX	X(X)	Not recommended before pea, bean or soya. Risk of sclerotinia before rape and sunflower.	Positive effect on cereals, beet, potato and flax.	XXX	XXX	XXX	X	X	XX	XX	XX	XX	XXX	X
Spring bean	T	XX		XXX	XX			XXX	XX	XXX	XX	X	XXX	XX	XX	XX	XX	XX*
Grass pea	T	XX		XXX	XX(X)			XXX	XXX	XXX	XX	X	X	XX	XX	XX	XX	X
Fodder lentil	T	XXX		XXX	XX			XXX	XX	XXX	XX	X	XXX	XXX	XX	XX	XX(X)	X
Hungarian millet	F			X	XXX	Not recommended before cereals.		X	XXX	XXX	X	X	XXX	XXX	XXX	XX	XXX	XX
Mustard	T	XX	XX	XX	XX(X)	Risk of seed growth and clubroot on rape. Risk of depressive effect on maize, and flax if destroyed late. Rick of sclerotinia on pea, bean, soya, rape and sunflower (risk is low if no sclerotium production). Not recommended before beet (nematode risk and weeding).	Positive effect on wheat on wheat. Positive effect on nematodes in beet (if anti-nematode).	XXX	XXX	XX	XXX	X	XX	XXX	XX(X)	XXX	XXX	XX
Turnip rape	T	XX	XX	XX	XXX			XXX	XXX	XXX	XXX	X	X	X	X(X)	XXX	XXX	XX

* Farm seed

Help sheet H4 :

Help with choosing cover crops (Step 1b, 2a)

	Soil improvement			Nutrient management		Pest management				Technical aspects (sowing and destruction)								Cost (not including volunteers)
										Sowing dates			Destruction method					
	Root system	Root exploration	Participation in stability of soil structure	Supply of nitrogen	Nitrogen trap	Negative effects	Positive effects	Appetence for slugs	Weed control	Post-harvest	End August/ start September	From September	Frost	Mechanical destruction	Chemical destruction	Ease of sowing	Speed of establishment	*Reference year: 2006*
Niger	T	XX	XX	X	XXX	Not recommended before pea, bean and soya. Risk of sclerotinia before rape and sunflower.		X	XXX	XXX	XX	X	XXX	XXX	XXX	XXX	XXX	XXX
Phacelia	T	XXX	XX	X	XX	Weeding risk before rape.	Breaks parasite cycle.	XXX	XXX	XX	XXX	X	XX(X)	XX	XX(X)	X	XXX	X
Field pea	T	X	X	XXX	XX	Not recommended before pea, bean and soya. Risk of sclerotinia before rape and sunflower.		X	XX	XXX	XXX	X	XX	XX	XX	XX	XX	X
Protein pea	T	X	X	XXX	XX			X	XX	XXX	XXX	X	XX	XX	XX	XX	XX	X
Fodder radish	T	XXX	XX	X	XXX	Risk of sclerotinia on pea, bean, soya, rape and sunflower (risk is low if no sclerotium production). Risk of clubroot on rape. Destroy early before crucifers (allelopathic effects). Choose anti-nematode varieties before beet.	Positive effect on wheat on wheat.	XXX	XXX	XXX	XXX	X	X	XX	XXX	XXX	XXX	XX
Chinese radish	T	XXX	XX	X	XXX			XXX	XXX	XXX	XXX	X	XX	X	XXX	XXX	XXX	X
Italian rye-grass	F	XXX	XXX	X	XX(X)	Risks linked to parasitism before cereals. Allelopathic effects if destroyed late before spring barley. Weed and nitrogen risk.		X	X	XXX	XXX	X	X	X	XXX	X	XXX	XX
Buckwheat	T		XXX	X	XXX	Weed risk.		X	XX	XXX	XX	X	XXX	XX	XXX	X	XXX	X
Rye	F	X	XXX	X	XX	Risks linked to parasitism before cereals. Allelopathic effects if destroyed late before spring barley. Risk of stem nematodes before beet.		X	XX	XXX	XXX	XX	X	X(X)	XXX	XX	XX	X
Fodder rye	F	X	XXX	X	XX			X	XX	XXX	XXX	XX	X	X(X)	XXX	XX	XX	X
Fodder sorghum	F			X	XXX			X	XX	XXX	X	X	XX	XXX		X	XXX	XX

Help sheet H4 : Help with choosing cover crops (Step 1b, 2a)

	Soil improvement			Nutrient management		Pest management				Technical aspects (sowing and destruction)								Cost (not including volunteers)
										Sowing dates			Destruction method					
	Root system	Root exploration	Participation in stability of soil structure	Supply of nitrogen	Nitrogen trap	Negative effects	Positive effects	Appetence for slugs	Weed control	Post-harvest	End August / start September	From September	Frost	Mechanical destruction	Chemical destruction	Ease of sowing	Speed of establishment	*Reference year: 2006*
Egyptian clover	T	XXX	X	XXX	XX	Not recommended before pea, bean and soya. Risk of sclerotinia before rape and sunflower.		X	XX	XXX	XX	X	XXX	X	XX(X)	X	XX	XX
Crimson clover	T	XXX	X	XXX	XX			X	XX	XXX	XX	X	X	X	XX(X)	X	XX	X
Purple clover	T	XXX	X	XXX	XX			X	XX	XXX	XX	X	X	X	XX(X)	X	XX	X
Sunflower	T	XXX		X	XXX	Risk of sclerotinia before pea, bean, soya, rape, flax and sunflower.		X	XX	XXX	XXX	X	XXX	XXX	XXX	XXX	XXX	XXX	XX
Spring common vetch	T	XX	X	XXX	XX	Not recommended before pea, bean and soya. Risk of sclerotinia before rape and sunflower.	Breaks parasite cycle except for hosts of sclerotinia.	X	XXX	XXX	XX	X	X	XX	XXX	XX	XXX	X
Hairy vetch	T	XX	X	XXX	XX				XXX	XXX	X(X)	X	X	XXX	XX(X)	XX(X)	XX	X
Purple vetch	T	XX	X	XXX	XX				XXX	XXX	X(X)	X	X	XX	XXX	XX(X)	XX	X
Winter common vetch	T	XX	X	XXX	XX				XX	XXX	XX	X	X	XX	XXX	XX(X)		X
Vetch + oats	TF	XXX	XXX	XX	XXX	Not recommended before cereals. Risk of sclerotinia before rape and sunflower.	Positive effect on maize, sorghum, beet and potato.			XXX	XXX	XX	XX	X	XX	XX		
White mustard + phacelia + Egyptian clover	TF			X	XXX	Risk of sclerotinia.	Positive effect before cereals, beet and potato.			XXX	XXX	X	XX	XX	XX	XX		

XXX Cover crop with favourable characteristics for the criteria under consideration

XX Cover crop with average characteristics for the criteria under consideration

X Cover crop with unfavourable characteristics for the criteria under consideration

Information not available

NB: Nitrogen supply for the following crop is higher if the crop reaches a high level of growth and is destroyed late.

N supply	X	0 to 10 kg N/ha
	XX	10 to 20 kg N/ha
	XXX	20 to 30 kg N/ha

Cost	X	Less than € 20
	XX	From € 20 to € 40
	XXX	More than € 40

Remarks

This information is valid for production of dry matter equivalent to 2 t/ha.
The participation of the cover crop to the stability of soil structure is weak and, above all, only short term.
The ease of sowing and speed of establishment depend on the sowing date.
Finally, the use of a mix of cover crops makes it possible to benefit from the effects of each crop and ensure soil coverage if there is a growing problem in one variety.

Sources :

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Help sheet H5 :
Classification of practices contributing to pest control at the field level according to efficacy (Step 2b)

Efficacy of practices on diseases

Principal levers	Rotation Choice of variety Combinations of varieties, species *Known combinations of actions :* *- Rotation x tillage* *- Variety + sowing date + density + management of nitrogen availability*
Secondary levers (to be combined)	Health quality of seeds Tillage Shredding of residues Management of volunteers Date and density of sowing Management of nitrogen availability
Supplementary levers	Biological control Chemical control

Efficacy of practices on weeds

Principal levers	Rotation (alternating sowing periods) Tillage Sowing date *Known combinations of actions :* *- Rotation x tillage* *- Choice of variety + sowing date + sowing density + management of nitrogen* *- Stale seed beds + sowing date + choice of variety + hoeing* *- Rotation + stale seed beds + sowing date + choice of cover crops*
Secondary levers (to be combined)	Health quality of seeds Early stubble cleaning (post-harvest) Stale seed beds Sowing density Management of nitrogen availability Choice of variety
Supplementary levers	Mechanical control Chemical control

Efficacy of practices on animal pests

Principal levers	Rotation *Known combinations of actions :* *- Varieties + sowing date + density*
Secondary levers (to be combined)	Tillage Shredding of residues Management of volunteers Stubble cleaning (slugs) Sowing date Trap crops Management of nitrogen availability Combinations of species, varieties Varietal resistance/tolerance
Supplementary levers	Biological control Chemical control

x : Indivisible practices – strong interactions
+ : Practices to be combined – weaker interactions

Help sheet H5 :
Classification of practices contributing to pest control at the field level according to efficacy (Step 2b)

Principal levers are those which can have good efficacy used on their own.
Secondary levers have only limited efficacy used on their own and should therefore be combined.
Supplementary levers make it possible to limit injury once pest populations are established in the crop. They are to be used as a remedial solution in the last resort.

Remarks

The combinations identified in the table are known combinations proven to work.
The practices have been classified according to expert opinion.

The table does not take into account all the interactions which can exist: for example, the management of animal pests can have an influence on the management of diseases since some of the former are vectors for the latter. Similarly, the management of weeds can have an effect on the management of diseases since weeds can be vectors for diseases affecting crops.

Help sheet H6 :
Known combinations of alternative methods for the control of pests (Step 2b)

	Actions on initial pest population	Actions on crop status	Actions on initial pest population and the crop status
Diseases	Lengthening of rotation with a reduction of the frequency of the return of straw cereals + suppression of wheat volunteers for controlling eyespot in wheat. Lengthening of rotation with a reduction in the frequency of the return of straw cereals x adaptation of tillage for the rotation for controlling eyespot in wheat.	Choice of hardy varieties or combinations of varieties + late sowing + reduction in sowing density + reduction in nitrogen inputs to control foliar diseases in wheat. Choice of varieties with low susceptibility + early sowing + reduction in sowing density + reduction in nitrogen inputs to control Phoma in oilseed rape.	Lengthening of rotation with a reduction of the frequency of the return of straw cereals x adaptation of tillage for the rotation + late sowing + reduction in sowing density (CMP 'integrated wheat' for the control of diseases). Lengthening of rotation with a reduction in the frequency of the return of straw cereals x adaptation of tillage for the rotation + late sowing + reduction in sowing density (CMP 'integrated wheat' for the control of diseases).
Weeds	Diversification of crops in the rotation x adaptation of tillage for the rotation and for the biology of weeds for controlling weeds in wheat.	Choice of competitive varieties + early sowing + increase in sowing density + increase in nitrogen availability for the crop to control weeds in rape. Choice of competitive varieties + dense sowing + mechanical weeding for the control of weeds in spring barley. Stale seed beds + late sowing + choice of competitive varieties + hoeing for the control of weeds in spring crops (maize, beet and sunflower).	Diversification of crops in the rotation x adaptation of tillage for the rotation and the biology of weeds + choice of competitive varieties + late sowing + increase in the sowing density (CMP 'integrated wheat' for the control of weeds). Diversification of crops in the rotation + introduction of cover crops + stale seed beds + late sowing + mechanical weeding for control of weeds in cropping systems with resistance to herbicide problems.
Animal pests		Choice of 'robust' varieties + early sowing + reduction in sowing density + adjustment of nitrogen fertilisation to the needs of the crop (for example, insects in rape).	Lengthening of rotation with a reduction of the frequency of the return of straw cereals x adaptation of tillage for the rotation + late sowing + reduction in sowing density (CMP 'integrated wheat' for the control of animal pests). Lengthening of rotation with a reduction in the frequency of the return of maize x tillage (stubble cleaning/ploughing) + shredding of canes for the control of European corn borer and other boring insects in maize + advancing of harvest date.

x : Inseparable practices – strong interactions
+ : Practices to be combined – weaker interactions

Help sheet H7 :

Examples of antagonisms of practices on different pests

(Step 2b)

Practice	Pest controlled	Negative effects on other pests
Increase in sowing density	Weeds	Encourages development of fungal diseases Encourages lodging
Increase of the nitrogen level in soil (for nitrophilous crops such as oilseed rape)	Weeds	Encourages development of fungal diseases
Burying of crop residues (ploughing)	Diseases	Disrupts the cycle of beneficials => reduces their control of animal pests
Combination of species	Diseases	Can increase harvest damage caused by animal pests through a concentration effect
Sowing of some cover crops in fallow periods	Nematodes	Slug injury Can encourage the development of some diseases

N.B.: The 'secondary effects' of these practices are not described here (for example, increasing erosion problems through ploughing in susceptible soils). They are however described in the practical sheets produced by RMT SDCI[a].

Help sheet H8 :
Typology of pests (Step 2b)

Objectives

To offer preferred practices to be implemented by farmers, according to the biological character of the pest concerned.

Criteria used and implications for cropping practices

→ **For diseases**

Disease characteristics	Implications for preferred practices
Dispersion distance: field, farm, district, region or national scale	• If the inoculum is within the field, favour practices which manage inoculum • If beyond the field, these practices are not effective • If dispersion is over a limited area, communal management is possible at the regional level
Persistence (in number of years)	• Management of tillage to ensure inoculum stocks are not brought to surface and adapting the period before return of susceptible crops
Biotrophic/saprotrophic	• Management of crop residues (burying for saprotrophic diseases)
Contamination periods	• Avoidance (rationalise sowing date)
Sensitivity to crop density	• Rationalise sowing density
Sensitivity of trophic state of the crop (principally nitrogen nutrition)	• Rationalise inputs, notably fertilisation

→ **For animal pests**

Pest characteristics	Implications for preferred practices
Dispersion distance: field, farm, district, region or national scale	• If the initial population is within the field, favour practices for the management of this population • If beyond the field, these practices are not effective • If dispersion is over a limited area, communal management is possible at the regional level
Persistence (persistence of eggs, in number of years)	• Adapt the time before the return of susceptible crops
Risk periods	• Avoidance (rationalise sowing date)
Sensitivity to crop density	• Rationalise sowing density
Sensitivity of trophic state of the crop (principally nitrogen nutrition)	• Rationalise inputs, notably fertilisation
Natural enemies	• Better management of pest's natural enemies

→ **For weeds**

Weed characteristics	Implications for preferred practices
Dispersion distance: field, farm, district, region or national scale	• If the initial population is within the field, favour practices for the management of the seed bank • If beyond the field, these practices are not effective
Persistence (weed seeds, in number of years)	• Management of tillage to ensure viable seeds are not brought to surface
Preferred emergence periods	• Avoidance (rationalise sowing date) and rationalise the rotation
Competitivity (bearing, foliar surface, growth rate etc.)	• Rationalise sowing date and density Choice of variety to have a competitive crop
Nitrophilous	• Rationalise fertilisation
Quantity of seed produced and germination potential	• Determination of risk induced by the presence of the weed => introduction of more or less powerful control methods
Sensitivity to climate	• Rationalise sowing date and rotation (alternate spring and autumn crops etc.)

Disease	Crops concerned	Dispersal distance of inoculum	Persistence	Existence of saprotrophic preservation	Contamination periods	Sensitivity to crop density	Sensitivity to crop's nitrogen nutrition
Take-all *Gaeumannomyces graminis*	Wheat>barley>triticale	Field	1 (or less)	yes	Primary infestations in autumn – avoid early sowing	High sowing density favours propagation of the disease (propagation by the roots)	Assimilation of nitrates in the autumn favours the disease; restriction of available nitrogen increases injury
Septoria leaf blotch *Septoria tritici*	Wheat, rye, triticale, flax	District/ small region	2	yes	From autumn, winter, spring	High sowing density increases disease risk	The higher the N concentration in the leaf, the greater the injury

For more information :

- Hyppa platform for the characterisation of weeds : **www.dijon.inra.fr/hyppa**
- Hyppz platform for the characterisation of animal pests : **www.inra.fr/hyppz**
- Hyp3 platform for the characterisation of pathogens: **www.inra.fr/hyp3**

www.systemesdecultureinnovants.org

www.endure-network.eu

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